

Smoke Detector Legislation: Its Effect on Owner-Occupied Homes

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Abstract: Montgomery County, Maryland was the first major jurisdiction to pass a law requiring smoke detectors in all homes. Smoke detector coverage in the county was evaluated five years after the law's implementation and compared to the coverage in neighboring Fairfax County, Virginia, which has no such law. Firefighters visited 651 randomly selected owner-occupied homes and tested each detector. While a similar percentage of homes in Montgomery and Fairfax counties complied with detector codes (42 per cent vs 44 per cent, respectively), Montgomery County had a significantly lower percentage of homes with no working detectors (17 per cent vs

30 per cent) and with no detectors at all (6 per cent vs 16 per cent). In general, Montgomery County residents complied with what they believed the law required, but lacked knowledge of the law's details. New homes where building codes required detectors and homes where owners assumed that detectors were required by law were likely to have working detectors. Analyses of 12 years of fire data suggest that as a county approaches complete detector coverage, the risk of residential fire deaths decreases. An essentially unenforced law seems to be obeyed because it conforms to community values. (*Am J Public Health* 1985; 75:858-862.)

Introduction

In 1980, 4,509 Americans died in home fires.¹ In addition, fire caused 31,000 reported civilian injuries, 200,000 unreported injuries, and \$6.5 billion in direct property losses.²

Three aspects of fatal fires suggest that early detection is a means of reducing fire deaths: 1) fatal residential fires most commonly occur when residents are asleep;³ 2) fatal fires burn for long periods of time before they are discovered;⁴ 3) most deaths are due to smoke inhalation rather than burns.⁵

The residential smoke detector provides an early warning of home fires.⁶ Its technology was developed in the 1960s, and it became commercially available by the end of the decade. It was estimated that in 1970, less than 5 per cent of American households had installed detectors. Respondent self-reports to three national telephone surveys indicate that placement rose to 22 per cent in 1977,⁷ to 46 per cent in 1980,⁸ to 67 per cent in 1982.⁹ This rapid adoption is attributed to marked reduction in price, intensive marketing campaigns, programs by local fire departments, building code modifications, and legislation.

In 1975, the BOCA (Building Officials and Code Administrators International) building code was amended to require a smoke detector protecting the bedroom area in each dwelling unit of one-, two-, and multi-family dwellings. A federal report of 1977 indicated that 18 states had passed some kind of statewide residential smoke detector legislation, primarily aimed at new construction and multi-family dwellings.¹⁰ A summary of state smoke detector legislation published in 1983 indicates that 29 states now require smoke detectors in all new classes of residential construction, and 22 states require one or more classes of residential housing to be retrofitted with smoke detectors.¹¹ No systematic evaluation has been published on the effectiveness of any of these laws in increasing detector coverage.

Montgomery County, Maryland was the first major jurisdiction in the United States to adopt a "retrofit" law which required that smoke detectors be installed in all homes. This followed extensive debate on the requirement's consti-

tutional and legal implications.¹² The law, which required a detector for each separate sleeping area and in stairways leading to occupied areas, was passed in September 1976, with an effective date of July 1978. Its fifth anniversary prompted county fire officials and an injury control researcher to collaborate on an evaluation study. Fairfax County, Virginia, which is similar in demographic and socioeconomic characteristics but which requires only that smoke detectors be installed in new construction, agreed to participate as the control county.

Methods

Sample Selection

Montgomery County, Maryland and Fairfax County, Virginia are suburbs within the Washington, DC metropolitan region. In demographic and socioeconomic characteristics, they are quite similar. Information from the 1980 census is as follows: population size (Montgomery County: 579,000 vs Fairfax County: 597,000); number of households (207,000 vs 205,000); percentage which graduated from high school (87 per cent vs 89 per cent); married couple as head of household (62 per cent vs 67 per cent); median family income (\$33,700 vs \$33,200); median value of owner-occupied homes (\$97,400 vs \$95,200).

Current county tax assessors' lists were used to draw a systematic random sample of all owner-occupied, single family homes in each county, 500 homes in Montgomery County and 400 in Fairfax County. Information from the tax lists included first and last name of deed signatories, address, census tract, and dollar value of land and house. The drawn sample and the completed sample in each county mirrored the distribution of the county population among fire station response areas. The median value of owner-occupied houses in the study sample was similar to that reported in the 1980 census for each county.

Interviewer Recruitment and Training

In Montgomery County, which has 16 independent fire departments, firefighters and ladies' auxiliary members were recruited as interviewers; in Fairfax County, which is served by a single department, firefighters were so assigned. For paid personnel, all training and data collection occurred during on-duty time. Attendance at a three-hour training session was mandatory for all interviewers, most of whom had had some experience with home inspections but lacked

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experience in survey research or in gaining entrance when not previously invited by the householder.

Assignment of Dwelling to Status Category

The outcome measure was the status of the dwelling with regard to smoke detector protection. Such protection was not defined as a unitary concept but as falling into five categories:

Status A, EVERY LEVEL—Dwelling conforms to National Fire Protection Association current code (NFPA 74 1978)¹³ which requires a detector for each separate sleeping area and on every level of the dwelling.

Status B, YES BY CODE—Dwelling conforms to past code (NFPA 74 1976) which requires a detector for each separate sleeping area and in stairways leading to occupied areas. This is the current Montgomery County law.

Status C, WORKING DETECTOR(S)—Dwelling has at least one working detector, but not in sufficient number or location to comply with either code.

Status D, NONE WORKING—Dwelling has detector units in home, but these are either not working or not installed.

Status E, NO DETECTOR—Dwelling has no detector.

Home Interview and Inspection

The interview form was a 17-page, 98-question instrument. An informed consent statement to be signed prior to the interview was included in the form. Responses to questions about knowledge of the law, fire safety practices, and experience with real and nuisance alarms were pre-coded except on two open-ended questions. Each detector was tested, using an aerosol product which mimics the by-products of combustion and should trigger a properly functioning detector. The status of each household was determined by the interviewer after noting the number, location, and working condition of installed detectors. The visit was designed to take no longer than one half hour.

There was concern about refusals by Montgomery County homeowners fearful of being caught not in compliance with the law. To avoid this, the Project offered to give away enough battery-powered, photo-electric detectors to bring non-complying households into compliance in return for survey participation.

Data Collection, Management and Analyses

Data collection began in the first week of July 1983. The project director reviewed each questionnaire and contacted the interviewer if necessary for clarification. Fairfax County completed work at the end of October, while Montgomery County continued until mid-December. An unobtrusive measure using names on the tax lists assured staff that firefighters had actually gone to assigned households.

Linear logistic models were generated for predicting at least one working detector for households in Montgomery County, in Fairfax County, and for the counties combined. Fourteen variables were entered into the model, and then eliminated in a backward procedure until only those making a significant contribution ($p < 0.05$) to prediction remained.

Fire data were collected from the two counties for the years 1972–83. The number of fires in single-family homes in each county was available only from 1976–83.

Results

Seventy-two per cent of the original sample in each county had completed interviews. In Montgomery County, 10.6 per cent were not at home after three attempts to complete the interview, 10.8 per cent refused, and 6.4 per

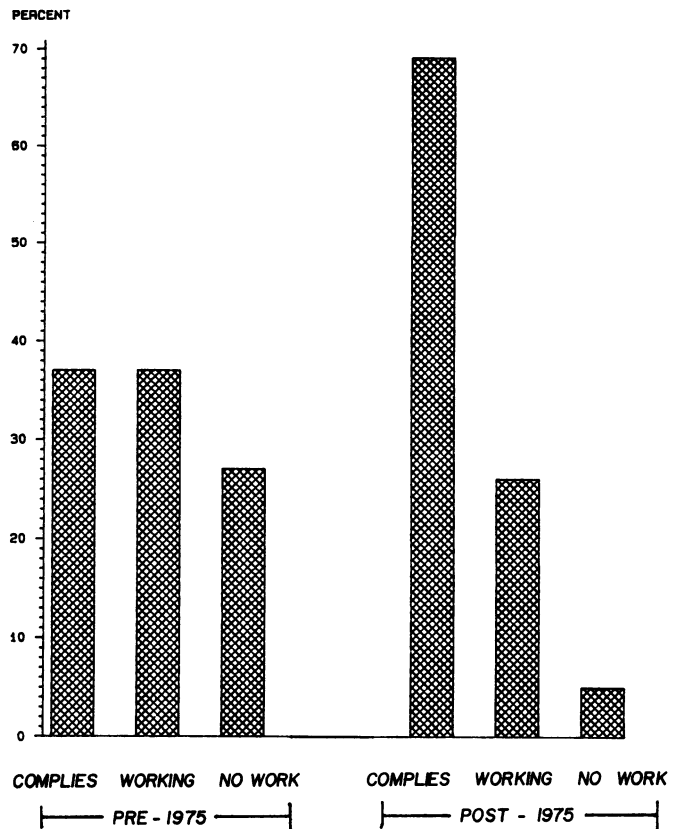


FIGURE 1—Distribution of homes built before 1975 and since 1975 according to category of detector protection. Homes built since 1975 were subject to building code requirements for detector installation
Complies = Complies with either NFPA 74(1978 or 1976)
Working = Has working detector(s), but does not comply with codes
No work = Has no working detector in home

cent were in the "other" category. In Fairfax County, 13.5 per cent were not at home, 6.3 per cent refused, and 7.8 per cent were "other". Cases assigned to the "other" category included homes occupied by tenants or housesitters, vacant homes, two homes where a language barrier prevented completion, and two lost questionnaires. The rates of no-one-home and refusals differed slightly between the two counties. Since property values for the original 900 homes were available, a chi square test for association between response category and quartiles of property values by county was calculated. No association was found.

Effect of Building Code Requiring Detectors in New Homes

Figure 1 illustrates the close association between detector protection and whether or not the home was built since 1975, when all new homes in both counties were required to have detectors. Sixty-nine per cent of such homes complied with one of the NFPA codes and an additional 27 per cent had at least one working detector.

Only 4 per cent of the homes built since 1975 had no working detectors compared to 27 per cent of the homes built before 1975. Two homes, both in Fairfax County, had no detectors, and an additional three homes, one in Fairfax County and two in Montgomery County, had detectors which were not functioning.

TABLE 1—Comparison between Category of Detector Protection in Montgomery County and Fairfax County

| | Montgomery % | n | Fairfax % | n | Total |
|---------------------|-----------------|-------|--------------|-------|-------|
| Every level | 15 | (53) | 20 | (56) | 109 |
| Yes by code | 27 | (97) | 24 | (70) | 167 |
| Working detector(s) | 41 | (145) | 26 | (76) | 221 |
| None working | 11 | (41) | 13 | (38) | 79 |
| No detector | 6 | (23) | 16 | (47) | 70 |
| | 100 | (359) | 99 | (287) | 646 |

Note: Two households in Montgomery County and three in Fairfax County refused permission to test detectors (most often because infants were asleep) and therefore these are not included in analyses involving category of detector protection.

Every level = Complies with NFPA 74(1978)

Yes by code = Complies with NFPA 74(1976)

Working detector(s) = Has working detectors but does not comply with NFPA codes.

None working = Has detectors, but not installed/working

No detector = Has no detectors

Effect of Retrofit Law in Montgomery County

Although the two counties were about equal in the percentage of households which complied with the NFPA codes, the differences in "working detector(s)" and "no detector" were substantial (Table 1). In Montgomery County, 82 per cent of the households had at least one working detector, compared to 70 per cent in Fairfax County; 6 per cent of households in Montgomery County had no detectors, compared to 16 per cent in Fairfax County. These differences cannot be explained by the 1975 building code requirements, since only 15 per cent of homes in the Montgomery County sample were built since 1975, compared to 25 per cent in the Fairfax County sample. The percentage of households whose detectors were non-functioning was about equal in the two counties.

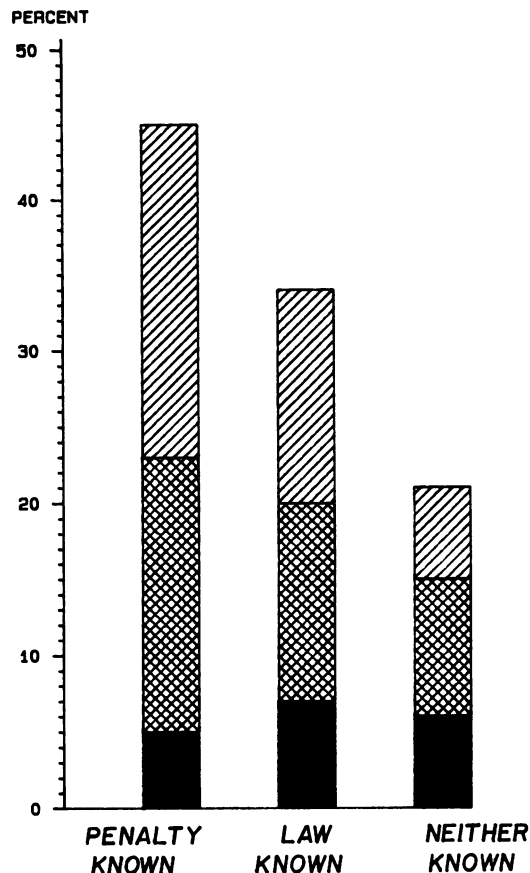
Knowledge of the Law

In Montgomery County, the majority of residents believed that they were required to "have smoke detectors", but were ignorant of the details of the regulation. Eighty per cent of the respondents knew or assumed that their county had a law requiring smoke detectors in all private homes, while 12 per cent answered "no" or "don't think so." An additional 8 per cent did not know. However, only 11 per cent knew that detectors were required for each separate sleeping area and stairwells leading to occupied areas.

There were two mechanisms for enforcement of the law in Montgomery County: 1) a fine and/or jail sentence was possible if detectors were not found by firefighters called to the home for a fire or other emergency; 2) the sale of a house was contingent upon certification that detectors were present.

There was a weak association between the transfer of deed within the past five years and detector protection in Montgomery County only ($p = .06$). However, only 28 per cent of the homes in Montgomery County were sold during this period.

While house fires and home sales affected only a minority of homeowners, the fact that there were penalties attached to the law appears to have had an effect on compliance. In Montgomery County, compliance was most likely among the 45 per cent of respondents who knew that penalties were attached to the law ("penalty known"), less likely in the 34 per cent of respondents who knew about the law but did not think that there were penalties attached ("law known"), and



COMPLIES **WORKING** **NO WORK**

FIGURE 2—Distribution of households in Montgomery County according to level of awareness of detector law and category of detector protection

Penalty known = Knows that law with penalties exists

Law Known = Knows about law but not penalties

Neither Known = Does not know about law or penalties

Complies = Complies with either NFPA 74(1978 or 1976)

Working = Has working detector(s), but does not comply with codes

No Work = Has no working detector in home

least likely in the 20 per cent of respondents who did not think there was a law ("neither known") (Figure 2).

Predicting the Presence of a Working Detector

The most important factor in all the linear logistic models was whether or not the home was built since 1975, the year the building codes required detectors (data available on request to author). Belief that the law required detectors was related to working detector presence in Montgomery County and both counties combined. Factors associated with economic variables (less income, low property values, number of stories in home) were also related to detector presence in Montgomery County. Households with income under \$25,000 dollars in Montgomery County (18 per cent of sample) were less likely to have detectors, although this was not true in Fairfax County where only 9 per cent of sample had income under \$25,000. Lower property value had a significant negative coefficient in Montgomery County; in Fairfax County, homes of one or two stories were less likely to have detectors than were homes of three or more stories.

Six variables examined by the study which were found

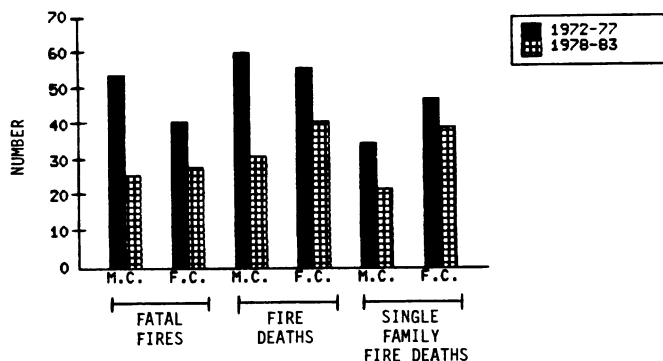


FIGURE 3—Number of residential fatal fires and number of residential fire deaths in Montgomery County (MC) and Fairfax County (FC) during the six-year periods before and after the law changed in Montgomery County.

not to be associated with detector protection and therefore were not entered into the models were: presence of smokers in home, whether or not children under age 10 or elders over age 65 lived in home, whether home was headed by married couple, the number of persons in household, and the education level of heads of household.

Maintenance of Smoke Detectors

In the 651 households inspected, there were 1,028 smoke detectors, of which 863 (84 per cent) sounded an alarm when tested; this percentage did not differ between the two counties. Eighty-one per cent of the 791 battery-powered detectors and 92 per cent of the 237 wired detectors passed the test. Among the battery-powered detectors which were non-functional, 32 per cent had no batteries, 51 per cent had dead batteries, and 17 per cent had other problems. Of detectors found in each county, 0.3 per cent were present but not installed.

Residential Fires and Fire Deaths

Figure 3 shows that reductions in fatal fires and in the number of deaths in the six-year period 1978–83 compared to 1972–77 were substantially greater in Montgomery County than in Fairfax County. (Yearly totals of fires and fire deaths available on request to author.) Moreover, in 1978–83, the number of fire deaths was less in Montgomery County than in Fairfax County, most strikingly for single family fire deaths. The latter observation is strengthened by two facts: there were more single family fires in 1978–83 in Montgomery County (2,559) than in Fairfax County (2,137); and only 15 per cent of the Montgomery County homes had been built since 1975, compared to 25 per cent of the Fairfax County homes.

Discussion

The two counties participating in the study are among the most affluent communities in the United States and, as such, have very low risk of fire deaths among their residents.¹⁴ The sample was confined to single-family homes. These limitations on generalizability can be addressed by replication of this study in rental and multi-family properties and in jurisdictions with different demographic and socioeconomic profiles.

Building code requirements for smoke detectors in new houses appear to be an effective but very gradual means to assure the presence of working smoke detectors in homes; only 19 per cent of the homes in the sample were built since

1975. Since the study showed that wired detectors are more likely to be working than are battery-powered detectors, building codes should require that detectors be wired into household current. A wall switch should not control the flow of current to the detector, a fault found in a few of the homes in the study.

A major argument against a retrofit smoke detector requirement was that it was unenforceable and therefore a bad law. However, the mechanism of requiring smoke detectors when a house is sold appears to have been effective in Montgomery County. In addition, the use of warning notices appears to have met with community cooperation. If firefighters found a home without detectors, a warning letter was sent by the Fire Marshal, which gave the resident 15 days to buy detectors and inform the Division of Fire Protection of compliance with the law. In the five years since passage of the law, approximately 500 warnings were delivered to residents. Only five summons were issued to appear in court, and only one, involving a landlord, resulted in a \$150 fine and 30-day suspended jail sentence.

The smoke detector law in Montgomery County, an essentially unenforced law for the majority of the population, seems to be obeyed, in part because it conforms to existing social values. Ninety-seven per cent of respondents in Montgomery County and 92 per cent in Fairfax County thought such a law was a good idea. In both counties, people who knew or assumed that they were required by law to have smoke detectors were more likely to have them.

However, Montgomery County residents were ignorant about the specific terms of their law. If the law conformed to the current standard which requires a detector on every floor, it would be easier to communicate and understand, and would afford better protection. A mass media campaign after changing the code might be considered in the future since most residents acknowledged mass media as the source of their information about the law, and a direct mail campaign proved ineffective in this study.

Fire deaths in both counties have decreased in the past six years, yet neither county has universal smoke detector protection in its single-family, owner-occupied homes. Seventeen per cent of Montgomery County homes in the sample had no working detector, as compared with 30 per cent in Fairfax County. As has been shown in seat belt use,¹⁵ unless compliance is virtually universal, the higher rates of deaths and injuries among high-risk populations are likely to mask the effectiveness of the device for the majority of people.

Intervention to prevent injuries can occur after, during, or before the damaging event. The control of life and property losses from fire once depended solely on fire department personnel and apparatus. Smoke detectors now add an early warning system to facilitate escape, and a law to assure installation appears effective. Residential sprinklers would immediately and automatically douse the fire at its origin, thus greatly reducing losses. However, to eliminate fire losses, work must continue on ignition sources like cigarettes,¹⁶ home heating devices, and electrical systems to prevent ignition of residential fires.

ACKNOWLEDGMENTS

The Project staff would like to thank, in Montgomery County, the Division of Fire Prevention and the Fire and Rescue Services which absorbed the costs of this study, the chiefs of the 16 independent fire departments, the Fire Board, former Fire Marshal James Dalton and Fire Marshal John Best; in Fairfax County, Chief Warren Isman, former Chief Alfred Savia and Chief Charles Dismuke; in both counties, the 83 firefighters and volunteers who collected these data, and the 651 residents who participated in the study; at Johns

Hopkins University, Ronald Brookmeyer, Allen Goodman, and Stephen Teret, who served as readers or advisors to this doctoral study.

REFERENCES

1. National Center for Health Statistics: Advance Report of Final Mortality Statistics, 1980: Monthly Vital Statistics Report 31. Hyattsville, MD: US Department of Health and Human Services, 1983.
2. US Fire Administration: Fire in the United States: Deaths, Injuries, Dollar Loss and Incidents at the National, State and Local Levels in 1981—Fourth Ed. Washington, DC: Federal Emergency Management Agency, 1983.
3. Mierley M, Baker SP: Fatal housefires in an urban population. JAMA 1983; 249:1466–1468.
4. Derry L: Fatal fires in America: where they happen, how they happen, how to stop them. Fire Journal 73–79.
5. Birky MM, Halpin BM, *et al*: Fire fatality study. Fire and Materials 1979; 3:211–217.
6. National Fire Prevention and Control Administration: Smoke Detector Technology. Washington, DC: US Department of Commerce, 1977.
7. National Fire Prevention and Control Administration: Survey and Analysis of Occupant-Installable Smoke Detectors: A Summary Report. Washington, DC: US Department of Commerce, 1978.
8. US Fire Administration: A Detector in Every Other Home: Summary of a Household Survey of Smoke and Fire Detector Owners. Washington, DC: Federal Emergency Management Agency, 1980.
9. US Fire Administration: Residential Smoke and Fire Detector Coverage in the United States: Findings from a 1982 Survey. Washington, DC: Federal Emergency Management Agency, 1983.
10. National Fire Prevention and Control Administration: Smoke Detectors and Legislation. Washington, DC: US Department of Commerce, 1977.
11. US Congress, Senate, Special Committee on Aging: Home Fire Deaths: A Preventable Tragedy. Washington, DC: 98th Congress, 1st Session, 1983.
12. Brannigan V: The legal implications of mandatory home fire detection. Fire Journal 1977; 71:1–7.
13. Household Fire Warning Equipment: 1978. Boston, MA: National Fire Protection Association, 1978.
14. Baker SP: The Injury Fact Book. Lexington, MA: Lexington Books, 1984.
15. Hurst PM: Compulsory seat belt use: further inferences. Accident Anal Prev 1979; 11:27–33.
16. McGuire A: Cigarettes and fire deaths. NY State J Med 1983; 83:1296–1298.

Conference on Community Injury Control

The University of Texas Medical Branch at Galveston and the Houston-Galveston Injury Prevention Group, will present the third in a series of conference's dedicated to injury control, on October 2–4, 1985, in Galveston, Texas.

Participants in this working conference will develop community based injury control strategies through the use of Galveston, Texas as a laboratory community.

Participants will: visit sites representing general injury control issues concerning water, pedestrians and non-motor vehicle traffic, crowds and violence; interact with experts in the fields of environmental design, alcohol control, legislation and local actions, and enforcement; drawing from workshop discussions, develop injury control solutions and strategies to issues raised by the site visits.

For further information please contact: Susan Brink, DrPH, Conference Director, Department of Pediatrics, The University of Texas Medical Branch, Galveston, TX 77550 (409) 761-1777.